

in particular adapted so as to avoid criticality and radiation effects and to minimize toxicity hazards.

(7) Process control instrumentation specially designed or prepared for monitoring or controlling the processing of material in a reprocessing plant.

[55 FR 30451, July 26, 1990, as amended at 58 FR 13005, Mar. 9, 1993. Redesignated at 61 FR 35603, July 8, 1996]

APPENDIX J TO PART 110—ILLUSTRATIVE LIST OF URANIUM CONVERSION PLANT EQUIPMENT AND PLUTONIUM CONVERSION PLANT EQUIPMENT UNDER NRC EXPORT LICENSING AUTHORITY

NOTE—Uranium conversion plants and systems may perform one or more transformations from one uranium chemical species to another, including: conversion of uranium ore concentrates to UO₃, conversion of UO₃ to UO₂, conversion of uranium oxides to UF₄ or UF₆, conversion of UF₄ to UF₆, conversion of UF₆ to UF₄, conversion of UF₄ to uranium metal, and conversion of uranium fluorides to UO₂. Many key equipment items for uranium conversion plants are common to several segments of the chemical process industry, including furnaces, rotary kilns, fluidized bed reactors, flame tower reactors, liquid centrifuges, distillation columns and liquid-liquid extraction columns. However, few of the items are available “off-the-shelf”; most would be prepared according to customer requirements and specifications. Some require special design and construction considerations to address the corrosive properties of the chemicals handled (HF, F₂, CLF₃, and uranium fluorides). In all of the uranium conversion processes, equipment which individually is not especially designed or prepared for uranium conversion can be assembled into systems which are especially designed or prepared for uranium conversion.

(a) Uranium Conversion Plant Equipment.

(1) Especially designed or prepared systems for the conversion of uranium ore concentrates to UO₃.

Conversion of uranium ore concentrates to UO₃ can be performed by first dissolving the ore in nitric acid and extracting purified uranyl nitrate using a solvent such as tributyl phosphate. Next, the uranyl nitrate is converted to UO₃ either by concentration and denitration or by neutralization with gaseous ammonia to produce ammonium diuranate with subsequent filtering, drying, and calcining.

(2) Especially designed or prepared systems for the conversion of UO₃ to UF₆.

Conversion of UO₃ to UF₆ can be performed directly by fluorination. The process requires a source of fluorine gas or chlorine trifluoride.

(3) Especially Designed or Prepared Systems for the conversion of UO₃ to UO₂.

Conversion of UO₃ to UO₂ can be performed through reduction of UO₃ with cracked ammonia gas or hydrogen.

(4) Especially Designed or Prepared Systems for the conversion of UO₂ to UF₄.

Conversion of UO₂ to UF₄ can be performed by reacting UO₂ with hydrogen fluoride gas (HF) at 300–500 °C.

(5) Especially Designed or Prepared Systems for the conversion of UF₄ to UF₆.

Conversion of UF₄ to UF₆ is performed by exothermic reaction with fluorine in a tower reactor. UF₆ is condensed from the hot effluent gases by passing the effluent stream through a cold trap cooled to –10 °C. The process requires a source of fluorine gas.

(6) Especially Designed or Prepared Systems for the conversion of UF₄ to U metal.

Conversion of UF₄ to U metal is performed by reduction with magnesium (large batches) or calcium (small batches). The reaction is carried out at temperatures above the melting point of uranium (1130 °C).

(7) Especially designed or prepared systems for the conversion of UF₆ to UO₂.

Conversion of UF₆ to UO₂ can be performed by one of three processes. In the first, UF₆ is reduced and hydrolyzed to UO₂ using hydrogen and steam. In the second, UF₆ is hydrolyzed by solution in water, ammonia is added to precipitate ammonium diuranate, and the diuranate is reduced to UO₂ with hydrogen at 820 °C. In the third process, gaseous UF₆, CO₂, and NH₃ are combined in water, precipitating ammonium uranyl carbonate. The ammonium uranyl carbonate is combined with steam and hydrogen at 500–600 °C to yield UO₂. UF₆ to UO₂ conversion is often performed as the first stage of a fuel fabrication plant.

(8) Especially Designed or Prepared Systems for the conversion of UF₆ to UF₄. Conversion of UF₆ to UF₄ is performed by reduction with hydrogen.

(9) Especially designed or prepared systems for the conversion of UO₂ to UCl₄ as feed for electromagnetic enrichment.

NOTE: Plutonium conversion plants and systems may perform one or more transformations from one plutonium chemical species to another, including: conversion of plutonium nitrate to PuO₂, conversion of PuO₂ to PuF₄, and conversion of PuF₄ to plutonium metal. Plutonium conversion plants are usually associated with reprocessing facilities, but may also be associated with plutonium fuel fabrication facilities. Many of the key equipment items for plutonium conversion plants are common to several segments of the chemical process industry. For example, the types of equipment employed in these processes may include the following items: furnaces, rotary kilns, fluidized bed

reactors, flame tower reactors, liquid centrifuges, distillation columns and liquid-liquid extraction columns. Hot cells, glove boxes and remote manipulators may also be required. However, few of the items are available off-the-shelf; most would be prepared according to the requirements and specifications of the customer. Particular care is essential in designing for the special radiological, toxicity and criticality hazards associated with plutonium. In some circumstances, special design and construction considerations are required to address the corrosive properties of some of the chemicals handled (e.g., HF). Finally, it should be noted that, for all plutonium conversion processes, items of equipment which individually are not especially designed or prepared for plutonium conversion can be assembled into systems that are especially designed or prepared for use in plutonium conversion.

(b) Plutonium Conversion Plant Equipment

(1) Especially designed or prepared systems for the conversion of plutonium nitrate to oxide.

The main functions involved in this process are: process feed storage and adjustment, precipitation and solid/liquor separation, calcination, product handling, ventilation, waste management, and process control. The process systems are particularly adapted so as to avoid criticality and radiation effects and to minimize toxicity hazards. In most reprocessing facilities, this process involves the conversion of plutonium nitrate to plutonium dioxide. Other processes can involve the precipitation of plutonium oxalate or plutonium peroxide.

(2) Especially designed or prepared systems for plutonium metal production.

This process usually involves the fluorination of plutonium dioxide, normally with highly corrosive hydrogen fluoride, to produce plutonium fluoride, which is subsequently reduced using high purity calcium metal to produce metallic plutonium and a calcium fluoride slag. The main functions involved in this process are the following: fluorination (e.g., involving equipment fabricated or lined with a precious metal), metal reduction (e.g., employing ceramic crucibles), slag recovery, product handling, ventilation, waste management and process control. The process systems are particularly adapted so as to avoid criticality and radiation effects and to minimize toxicity hazards. Other processes include the fluorination of plutonium oxalate or plutonium peroxide followed by reduction to metal.

[61 FR 35606, July 8, 1996, as amended at 65 FR 70291, Nov. 22, 2000]

APPENDIX K TO PART 110—ILLUSTRATIVE LIST OF EQUIPMENT AND COMPONENTS UNDER NRC EXPORT LICENSING AUTHORITY FOR USE IN A PLANT FOR THE PRODUCTION OF HEAVY WATER, DEUTERIUM AND DEUTERIUM COMPOUNDS

NOTE: Heavy water can be produced by a variety of processes. However, two processes have proven to be commercially viable: the water-hydrogen sulphide exchange process (GS process) and the ammonia-hydrogen exchange process.

A. The water-hydrogen sulphide exchange process (GS process) is based upon the exchange of hydrogen and deuterium between water and hydrogen sulphide within a series of towers which are operated with the top section cold and the bottom section hot. Water flows down the towers while the hydrogen sulphide gas circulates from the bottom to the top of the towers. A series of perforated trays are used to promote mixing between the gas and the water. Deuterium migrates to the water at low temperatures and to the hydrogen sulphide at high temperatures. Gas or water, enriched in deuterium, is removed from the first stage towers at the junction of the hot and cold sections and the process is repeated in subsequent stage towers. The product of the last stage, water enriched up to 30 percent in deuterium, is sent to a distillation unit to produce reactor grade heavy water; *i.e.*, 99.75 percent deuterium oxide.

B. The ammonia-hydrogen exchange process can extract deuterium from synthesis gas through contact with liquid ammonia in the presence of a catalyst. The synthesis gas is fed into exchange towers and then to an ammonia converter. Inside the towers the gas flows from the bottom to the top while the liquid ammonia flows from the top to the bottom. The deuterium is stripped from the hydrogen in the synthesis gas and concentrated in the ammonia. The ammonia then flows into an ammonia cracker at the bottom of the tower while the gas flows into an ammonia converter at the top. Further enrichment takes place in subsequent stages and reactor-grade heavy water is produced through final distillation. The synthesis gas feed can be provided by an ammonia plant that can be constructed in association with a heavy water ammonia-hydrogen exchange plant. The ammonia-hydrogen exchange process can also use ordinary water as a feed source of deuterium.

C.1. Much of the key equipment for heavy water production plants using either the water-hydrogen sulphide exchange process (GS process) or the ammonia-hydrogen exchange process are common to several segments of the chemical and petroleum industries; particularly in small plants using the